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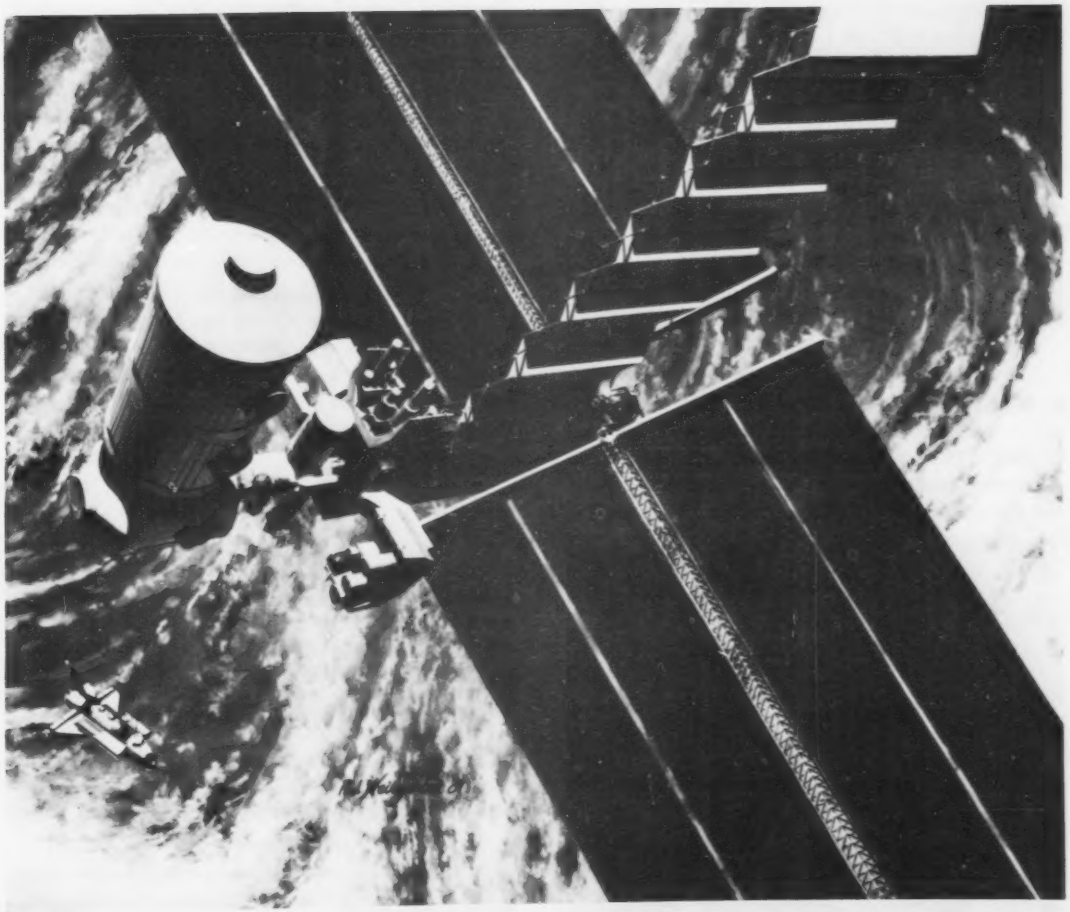
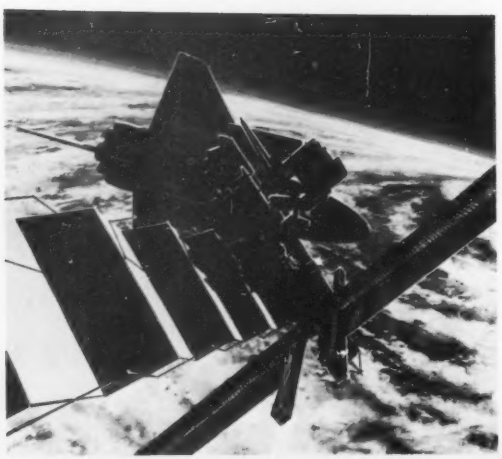


About the Cover

Space Station by 1990?—NASA believes a space station is the next logical step in the development and utilization of space. In a major address on space stations delivered to the Detroit Economic Club on June 23, NASA Administrator James M. Beggs emphasized a U.S. space station would "make a vital contribution to our nation's future by opening new vistas of science and technology, new possibilities for commercial applications of space and new opportunities to enhance economic security and national defense." (This speech will appear in the July edition of *NASA Activities.*) On the cover is one of several reference concepts for a space station under review at NASA under sponsorship of the agency's Marshall Space Flight Center, Huntsville, Ala. Conceived by TRW, Redondo Beach, Calif., the space platform modular concept is developed to one of its potentials as a manned structure. Below is the Space Shuttle docked with this platform deploying a payload with the Remote Manipulator System. (An article on space stations also will appear in the July edition of *NASA Activities.*)

Contents

Administrator's Column 3
Space Shuttle Flight Four—
Pre-flight Background 4
Student-Developed Projects to Fly on
Fourth Shuttle Mission 12
Nation's First Large Wind Turbine Cluster
in Full Operation 15
Scientific Evidence Reveals Venus Had Oceans .. 16
Spacelab Experiment Installation Begun 17
Space Techniques Separate Paintings Hidden
Beneath Master Works 18
Electric Rocket Engine Completes
11 Years in Space 19
Upper Stage Rocket Begins Checkout at KSC .. 21
Inspector General Activities 21
They've Got the Whole Shuttle in Their Hands .. 21
Contractor News 23
Did You Know? 26
Patents for Inventions 27
Space Shuttle Launches for 1982 27
Expendable Launches for 1982 27
Another Dividend from Air and Space 28



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Jacqueline McGowan
Editor, Code LFD-10
NASA Headquarters, FOB 6
Washington, D.C. 20546
Phone: (202) 755-8370

Administrator's Column

(Each month in this column *NASA Activities* will feature an article by NASA Administrator James M. Beggs. These articles will focus on subjects chosen by him to address topics of broad interest to the agency's employees.)

Merit Pay—Rocky Beginning But Smoother Road Ahead

The disappointment that NASA's merit pay employees experienced with their first payout for performance in 1981 will not be repeated in 1982. Agency funding available for merit pay salary increases will be twice as much as in 1981.

Almost 3,000 NASA management officials and supervisors were put under the new Merit Pay System in October 1981. Under the Civil Service Reform Act of 1978, each federal agency was charged with establishing a compensation framework for its GS-13, 14 and 15 supervisors and management officials based upon individual and organizational performance.

Under the old General Schedule (GS) pay system for all employees in grades 13 through 15, an individual's salary within a grade could be increased in several ways during a given year: (1) annual pay raise comparability adjustment granted to all Government employees by the White House and Congress each October; (2) within grade increase ("step increase") in accordance with a prescribed time schedule between steps; and (3) quality increase for outstanding performance.

For those under Merit Pay, in-grade steps have been removed. Employees receive one pay increase in October of each year, which includes one-half of the annual comparability increase given to GS employees and a merit pay component increase based upon performance ratings. Performance rating categories are unsatisfactory, minimally satisfactory, successful, highly successful or outstanding. Pay raises based upon these performance ratings are granted accordingly with larger increases for higher ratings.

The size of the merit pay component, while primarily a function of an employee's work appraisal, also is linked to present grade and salary and to funds available for pay increases from the "merit pay pool." Funding for the pool is derived from the amount of money normally spent on within grade and quality step increases plus one-half of the annual GS comparability increase.

The first payout under the Merit Pay System, however, did not in all cases meet the criteria of better pay for better performance. Many who earned high ratings under merit pay actually received smaller salary increases than GS employees who received in-grade raises. Thus, in those instances, supervisors who were expected to perform well both technically and as managers under merit pay were rewarded less for high performance than non-managerial employees at the same grade level.

The smaller payout resulted from a decision rendered by the General Accounting Office (GAO) *one month* before the Merit Pay System was placed into effect. In September 1981, the GAO determined that the Office of Personnel Management (OPM) had overestimated the amount of money agencies would have spent for within grade and quality increases for 1981. GAO thereby revised the computation used for determining this amount which, in turn, significantly reduced the funding available for merit pay pools in this first year.

In response to the GAO revision, OPM granted full comparability salary increases in 1981 to cushion the merit pool deficit. Salary increases received, however, were still substantially less than anticipated. But for 1982, the full merit pay pool will be operational and agencies will be able to give larger increases to its merit pay employees.

Nonetheless, for research and development agencies such as NASA, the Merit Pay System does not provide an adequate incentive program. At NASA, about 2,900 employees are merit pay management officials or supervisors at the 13 to 15 grade levels as compared to over 6,700 GS workers at the same levels.

Occupations in research and development uniquely provide employees with a dual channel opportunity for career advancement: either through individual accomplishment or managerial ranks. At NASA, this option is reflected by the unusual statistic of only one third of professionals in these grade levels being supervisors or management officials. Thus for NASA, the bulk of the work force in grades 13 through 15 does not fall under merit pay (as with most agencies) and is therefore not in competition for pay increases. For the group of employees charged with the dual responsibility of technical *and* managerial expertise, the merit pay component does not provide adequate reward for performance.

NASA is currently pursuing solutions to this pay system inequity in a two-fold manner: appeal to the

Office of Personnel Management and support of legislation designed to amend the system.

The Civil Service Reform Act contains a provision for agency exclusion from the Merit Pay System. NASA believes that it has been demonstrated that the system fails to provide an effective career incentive plan and is developing an appeal to OPM for exclusion. In the interim, however, the disparity of two pay systems can only be corrected by legislative action.

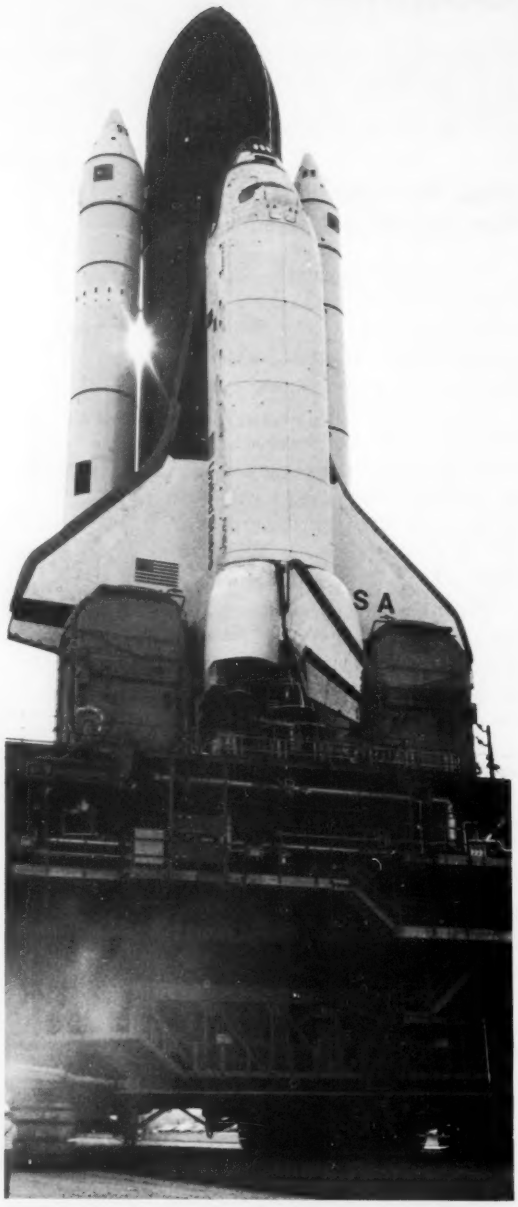
On March 4, Representative Frank R. Wolf (R-Va.) introduced legislation to replace the Merit Pay System in an attempt to "restore a measure of equity to the pay process for midlevel managers and supervisors in the Federal Government, GS-13 through 15."

Under Wolf's amendments, all satisfactory employees in these grades, not just managers and supervisors, would receive full comparability and step increases. For performance above the satisfactory level, Wolf proposes a "bonus pay system" be established. The minimum bonus proposed would be two percent of an employee's annual salary; the maximum not to exceed $10,000. Bonuses granted would be paid in one lump sum payment. Under this system Wolf believes "those employees who truly excel will enjoy a pay bonus commensurate with their efforts." NASA supports this legislation and has sent its endorsement to the Office of Management and Budget.

Space Shuttle Flight Four—Pre-Flight Background

Space Shuttle Columbia's fourth flight to be launched June 27 from NASA's Kennedy Space Center, Fla., is scheduled for seven days and will complete the shakedown of the Shuttle orbiter and booster systems as our nation's space transportation system becomes operational with flight five. Among top priorities listed for this mission are the continued studies of the effects of long-term thermal extremes on the orbiter sybsystems, a survey of orbiter induced contamination on the payload bay and a landing by the orbiter's autoland system.

Flight crew for the fourth Shuttle mission is commander Ken Mattingly, 46, and pilot Henry Hartsfield, 48. Mattingly, selected by NASA to be an astronaut in April 1966, was command module pilot



Rollout 4—Space Shuttle Columbia leaves Kennedy Space Center's Vehicle Assembly Building May 26 for its fourth rollout to Launch Pad 39A. This 3½-mile journey takes approximately eight hours to complete.

on Apollo 16, launched April 16, 1972. He has logged 265 hours in space—1 hour and 13 minutes of that time spent in extravehicular activity. Hartsfield has been a NASA astronaut since September 1969. He was a member of the astronaut support crews for Apollo 16 and Skylab missions 2, 3 and 4. Mattingly and Hartsfield were the backup crew for Shuttle flights two and three.

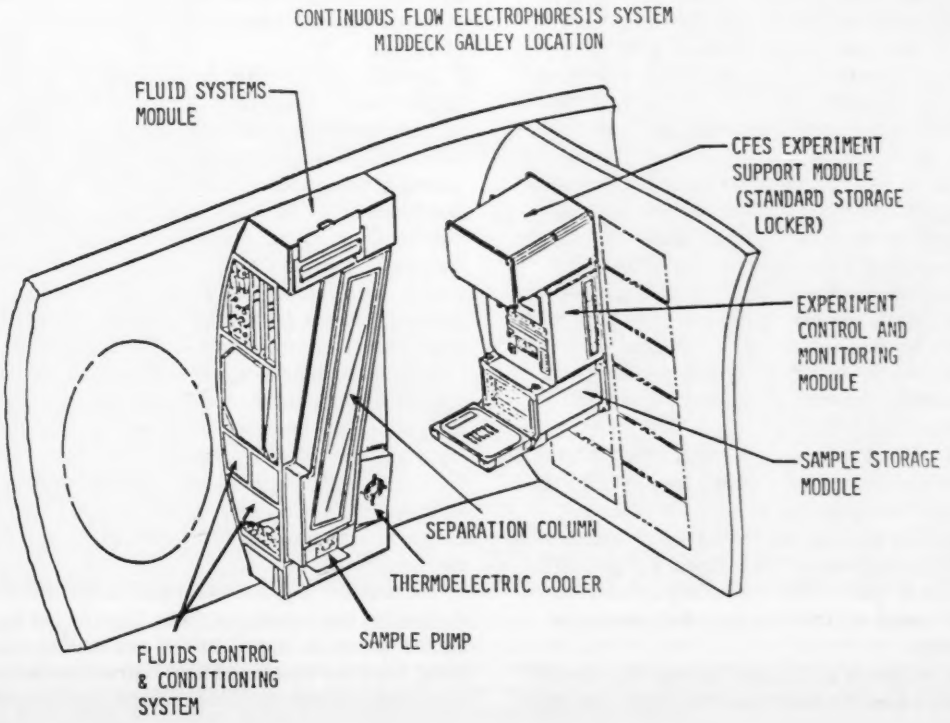
Columbia will be launched into a circular orbit above the Earth with an inclination to the equator of 28.5 degrees. Two burns of the orbital maneuvering system (OMS) engines will place Columbia in a 130 nautical mile (150 statute mile) circular orbit. A third and fourth burn of the OMS engines on the fifth revolution will place Columbia in a circular orbit 160 n. mi. (184 mi.) above the Earth.

Launch window for the fourth flight will last 4 hours, 24 minutes. The window tentatively will open at 11 a.m. EDT and extend until 3:24 p.m. for a nominal late June launch. The end of the window is restricted to a Trans-Atlantic abort into Dakar, Senegal no later than 15 minutes after sunset.

Columbia will operate in several different attitudes during the 169-hour flight. For the first 20 hours of the mission, the orbiter will rotate in a "barbeque" fashion in the Passive Thermal Control mode designed to stabilize the orbiter's systems in a relatively benign environment. For five hours the orbiter will fly with its top to the Sun, followed by 66 hours in an attitude where the tail faces the Sun. Columbia will then turn its broad belly toward the Sun for 33 hours. Prior to reentry, Columbia will fly the final 10 hours of the mission in a gravity gradient attitude.

Principal cargo to be carried on Shuttle flight four is a classified Department of Defense payload designated DOD 82-1. Other experiments will be carried in the cargo bay and in the orbiter's mid-deck.

An experiment that marks the first use of the Space Shuttle by a commercial concern tops the list of civilian payloads scheduled to be carried into space on this mission: the **Continuous Flow Electrophoresis System** experiment. This experiment will separate biological materials in a fluid according to their surface electrical charge and is part of a NASA/ McDonnell Douglas Astronautics Company "joint endeavor agreement" to conduct research in space. Scientists from the Ortho Pharmaceutical Division of



Johnson & Johnson are collaborating with McDonnell Douglas in this effort.

Unlike previous electrophoresis experiments in space, this system processes considerable quantities of materials carried in a continuous stream. This flight will serve as an initial engineering test of the McDonnell Douglas-provided experiment hardware and will involve the separation of proteins and other natural biological matter in six samples. Materials obtained from this experiment could lead to commercial marketing of new medicines unobtainable without the benefit of zero gravity.

Gravity limits the concentration of the materials in the sample being separated, which is one of the primary factors limiting the electrophoresis production of commercial quantities on Earth. On Earth, only 0.25 percent of the sample to be separated can be biological material; the rest must be carrier fluid. In space, however, the concentration can be increased to 20 percent or more of the total sample, thereby increasing the output of the process by a factor of 80 to 100 over Earth processing.

Also on Earth, the sample stream size must be restricted to minimize gravity-induced disturbances to measure only one-half millimeter in diameter, while in space the diameter may be increased to one millimeter. This increases the output of the process by a factor of four, and when combined with the increase from higher concentrations, can result in an overall increase in output of 300 to 400 times when compared to an Earth-based unit. In addition, purer materials can be obtained in space.

On Earth, heat caused by the electric current used in the separation process induces convection, which reduces the purity of the separated materials. In space, the voltage may be increased without causing disturbing convective flows. Also, in space the length of time that the material being separated is in the electric field may be increased without detrimental side effects. This, in conjunction with the increased voltage, can significantly improve the purity of the separated materials.

NASA's joint endeavor agreement with McDonnell Douglas is pioneered and managed for NASA by the Materials Processing in Space Projects Office at Marshall. Under such an agreement, private enterprise and NASA work together as partners to promote the utilization of space where a technological advancement is needed and there is a potential commercial application.

Joint endeavors are designed to contribute directly to NASA's scientific objectives in the field of materials

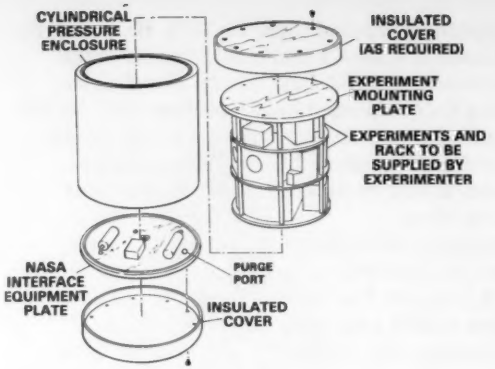


Diagram of NASA's container concept for "Getaway Specials" or Small Self-Contained Payloads.

processing and to simultaneously accelerate the benefits to the general public from this technology. With the Continuous Flow Electrophoresis System experiment, both McDonnell Douglas and NASA will benefit from the use of this equipment for space experimentation in materials science.

Program manager for this experiment is James Rose, McDonnell Douglas Astronautics, St. Louis, Mo.; joint endeavor agreement manager for the project is Walter Wood, Marshall Space Flight Center, Huntsville.

NASA's first **"Getaway Special"** will fly on this fourth mission. Inside the 2½ cubic foot canister will be nine experiments that range from algae and Duckweed growth in space to fruit fly and brine shrimp genetic studies. The Getaway Special was purchased by R. Gilbert Moore, a manager at the Thiokol Corp., Ogden, Utah. He subsequently donated the canister to Utah State University where it is being used in a program for student-constructed experiments. (For more information on these student experiments, see article on page 12 of this issue.)

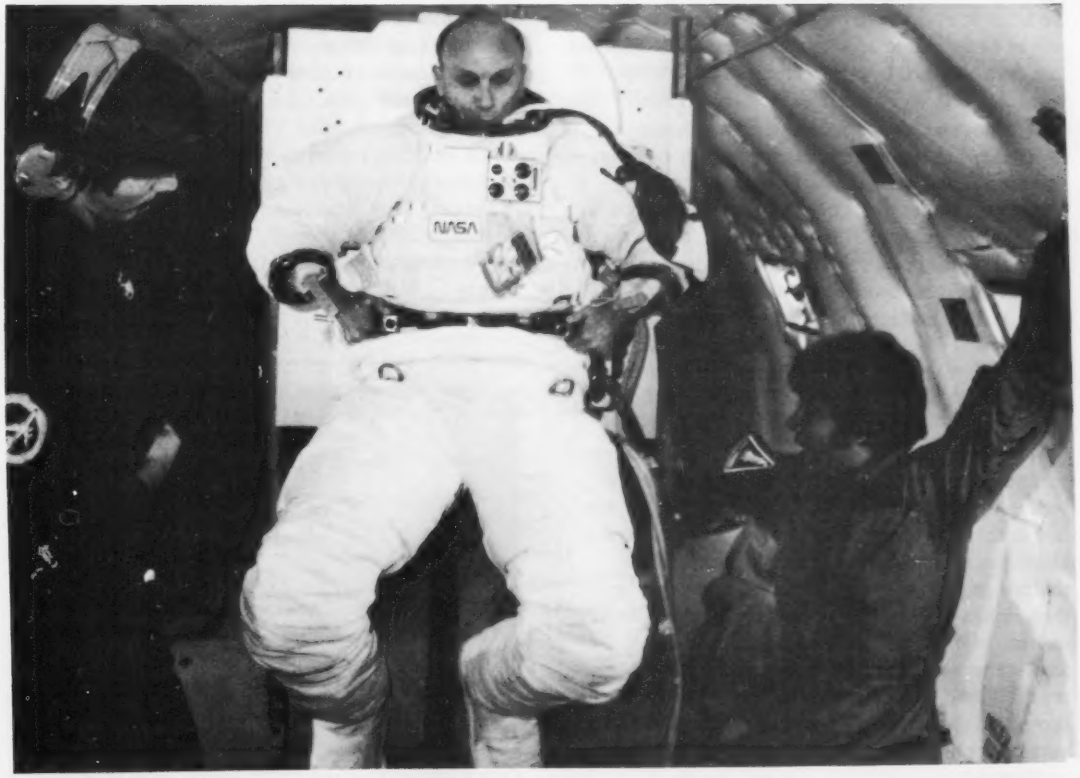
Several experiments will be making their third and fourth flights aboard the Shuttle. Among those carried on previous missions are: Developmental Flight Instrumentation Package, Aerodynamic Coefficient Identification Package and several orbiter experiments such as Catalytic Surface Effects, Tile Gap Heating Effects and Dynamic, Acoustic and Thermal Environment experiment.

The first four flights of the Space Shuttle are designed as engineering test flights to prove out the Shuttle system in launch, orbital and landing operations. The **Developmental Flight Instrumentation** is a data collection and recording package consisting of

three magnetic tape recorders, wideband frequency division multiplexers. a pulse code modulation master unit and signal conditioners. The recorders can record 28 tracks of wideband analog data on systems conditions and performance simultaneously. The Developmental Flight Instrumentation package will be removed after this flight from Columbia's cargo bay.

Primary objectives of the **Aerodynamic Coefficient Identification Package** are: (1) to collect aerodynamic data during launch, entry and landing phases of the Shuttle; (2) to establish an extensive data base for verification of the Shuttle's aerodynamic performance and correlation with ground-based data, including assessments of the uncertainties of such data; (3) to provide flight dynamics data in support of other technology areas such as aerothermal and structural dynamics. Instruments in this package include dual-range linear accelerometers and rate gyros. Also included are the power conditioner for the gyros, the power control system and the housekeeping components. The package is installed colinearly with the geometric axes of the orbiter and post-installation measurements made to establish the position within 10 arc minutes. The instruments continuously sense the dynamic X, Y and Z attitudes and performance characteristics of the orbiter through these flight phases. The Aerodynamic Coefficient Identification Package also provides high rate sampling of the positions of orbiter control surfaces for recording with the package's attitude data. Principal technologist is D. B. Howes of Johnson Space Center.

For the **Tile Gap Heating** experiment, the Columbia will be instrumented with a removable panel 45.7 cm



Pre-flight Weightlessness—Commander for the fourth flight of Columbia, Ken Mattingly, undergoes a suit donning and doffing exercise aboard a NASA KC-135 "zero gravity" aircraft. A special parabolic pattern flown by the aircraft provides a short period of weightlessness. Mattingly's spacesuit is an extravehicular mobility unit used by astronauts when leaving the shirt-sleeves environment of the orbiter to go outside and perform tasks in the vacuum of space. Although there are no plans for such activity on this flight, crewmen are trained in the procedures as an emergency contingency.

(18 in.) square, which will carry 11 tiles of baseline material and size fitted to the underside of the orbiter fuselage. Gaps between tiles will be carefully calculated and controlled during fitting to ensure that the heating rates generated during entry will be no higher than those of the baseline tile array. The aim is to produce a design that will result in heating rates lower than those of the baseline system.

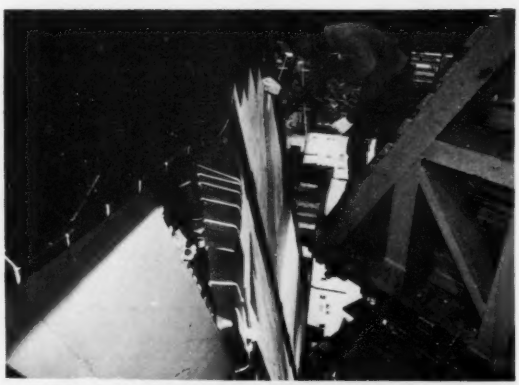
In addition to gap spacing, gap depth also will be controlled through the use of fillers fitted at the bottom of certain gaps; such as at the junction of the tiles and the orbiter fuselage skin. The radii at the outer edges of the tiles will be controlled during fabrication to conform to calculations that show the reduced effects in combination with the spacing. Thermocouples will be fitted to the tile surfaces and at various depths in the gaps to measure temperatures during re-entry. Output of the thermocouples will be recorded on the orbiter's developmental flight instrumentation. To assist in evaluation, tile gap heating effects data will be compared to developmental flight instrumentation data obtained from earlier missions. Principal technologist is W. Pitts, Ames Research Center.

A strong shockwave encompasses the Space Shuttle during atmospheric re-entry which severely compresses and heats the air flowing through it causing molecules to dissociate and react chemically with each other. As the dissociated atomic oxygen approaches the cooler regions of flow adjacent to the orbiter, it fails to recombine into molecular oxygen. The **Catalytic Surface Effects** experiment investigates the chemical reaction caused by impingement of atomic oxygen on the Shuttle thermal protection system which was designed under the assumption that the atomic oxygen would recombine at the thermal protection system wall. This chemical reaction releases additional heat which results in higher thermal protection system temperatures. In this case, the surface is referred to as being a catalytic surface because it allows the chemical reaction to take place. If the thermal protection system surface is non-catalytic, then atomic oxygen will not recombine into molecular oxygen, heating rates will be lowered, and the temperature of the orbiter during re-entry will be lower. With lower temperatures, orbiter thermal protection system weight could be reduced, its flight envelope could be expanded or greater reusability could result.

Catalytic Surface Effects will use baseline tiles, selected from those having developmental flight instrumentation thermocouples located on or near the orbiter lower fuselage centerline. The five tiles will be sprayed with an overcoating mixture of chrome-iron-spinel, a highly efficient catalytic material and a vinyl acetate binder which will protect the overcoat during ground operations. The mixture is compatible with the existing tile and coating and will not alter the thermal or mechanical properties of the uncoated portions of the thermal protection system. During orbiter ascent, the vinyl acetate will burn off the tile surface leaving the chrome-iron-spinel exposed.

Thermocouple measurements recorded during re-entry will be used to determine catalytic surface effects performance. Comparison of this experiment's data with data taken on previous flights from uncoated tiles will aid in the evaluation. At the end of mission, the overcoat will be removed from the five tiles leaving the thermal protection system in its original condition. Principal technologist is D. Stewart, Ames Research Center.

The purpose of the **Dynamic, Acoustic and Thermal Environment** experiment is to predict cargo-bay environments with accuracy and dispatch. These environments are neither constant nor consistent throughout the bay and are influenced by interactions between cargo elements. The experiment's instrumentation includes: accelerometers, microphones, thermocouples, and strain gauges on payloads and in the cargo bay. Sensor outputs will be recorded for post-flight interpretation. NASA's Goddard Space Flight Center, Greenbelt, Md., is responsible for the data reduction. Principal technologist is W. Bangs of Goddard.



Critical Inspection—Doug Joseph, quality inspector with Rockwell International, checks repairs to a thermal protection system tile on Columbia's vertical stabilizer. Over 30,000 tiles cover the body of the spacecraft to protect it from the thermal extremes of temperature encountered during the unique aerospace vehicle's ascent, on-orbit activities and re-entry.

The **Induced Environment Contamination Monitor** also will be making its third trip into space on the fourth flight of Columbia. The desk-sized package will "map" the contaminants around the cargo bay which may affect scientific experiments or other cargo on future flights. The package of 11 instruments developed by NASA's Marshall Space Flight Center, measures any induced atmosphere generated by off-gassing and outgassing from materials on board the Shuttle and from other contamination-producing Shuttle activities such as firing the attitude control jets and water dumps. The monitor also provides data on the interaction between the induced and natural environments.

In addition to regular in-place monitoring activities in the orbiter cargo bay during this seven-day flight, the crew will activate the Remote Manipulator System to pick up this package and place it at various locations around the orbiter. During this "mapping" exercise the monitor will employ an instrument added for this mission—the Plume Pressure Gauge—which will measure the pressure wave of the plume emitted by the firing of reaction control jets at the nose of the orbiter. The Induced Environment Contamination Monitor will be attached to a release mechanism (also developed by Marshall) enabling it to be freed and lifted up by the Remote Manipulator System.

The Induced Environment Contamination Monitor operates during pre-launch, ascent, on-orbit, descent, landing and 45 minutes after landing. The on-orbit measurements include molecular return flux, background spectral intensity, molecular deposition and optical surface effects. During other mission phases, dew point, humidity, aerosol content and trace gas will be measured.

Other experiments making their second trip into space include the Nighttime/Daytime Optical Survey of Lightning, flown aboard the second mission but produced limited results because of the shortened mission, and the Monodisperse Latex Reactor, a Shuttle Flight 3 passenger.

The **Nighttime/Daytime Optical Survey of Lightning** experiment is designed to record motion pictures and photo-cell readings of lightning and thunderstorms as seen from orbit. The lightning survey experiment concept was conceived by Principal

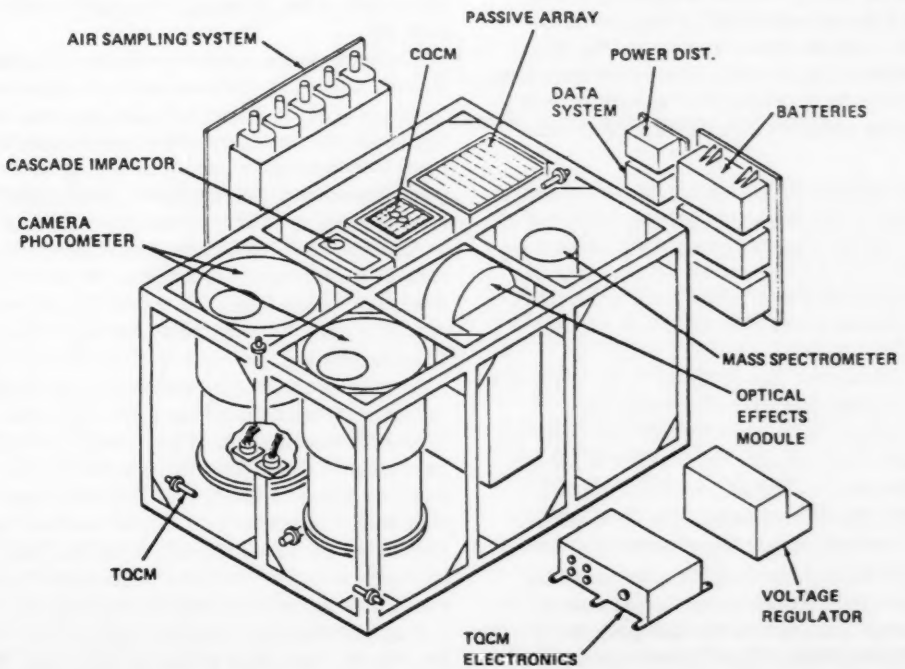


Diagram of the **Induced Environment Contamination Monitor** carried aboard the fourth Shuttle mission. The package will "map" the contaminants around the cargo bay which may affect scientific experiments.

Investigator Dr. Bernard Vonnegut of the State University of New York, Albany.

The experiment, to be conducted from the orbiter crew compartment, consists of a 16-mm data acquisition camera synchronized with a two-channel stereo cassette recorder receiving the output of a photocell optical system serving as a sensor. The camera-sensor system was built for Marshall by Johnson Space Center. The Shuttle astronauts will use the motion picture camera to film the lightning flashes of thunderstorms. A diffraction grating will be attached to the camera lens during nighttime observations to provide lightning spectrographs. This data can be used to determine the temperature, pressure, molecular species, electron density and percent of ionization in the lightning's path.

Lightning discharges will be sensed by the photo-optical system, which creates an electronic pulse in response to the detection of a lightning flash. These pulses will be recorded on magnetic tape. A lightning event, visible as only one flash, is usually composed of many separate discharges or strokes which are detected by the photocell. Thus the photocell also will be used during the night to record lightning strokes. The motion picture camera will be used during the day as well to film the cloud structure and the convective circulation in the storm. These techniques may be adaptable in the development of sensors to identify severe weather situations from future meteorological satellites.

The area of the Earth's surface in the view of the orbiting Shuttle is so large that lightning storms will probably be visible on almost every orbit. Because of the high speed of the spacecraft, these storms will remain in view only a short time—just a few seconds for storms directly beneath the flight path and somewhat longer for those off to either side. During passages over the dark side of the Earth, the astronauts will readily recognize nocturnal storms by their lightning flashers which should be visible for hundreds of kilometers. On the sunlit side of the Earth, the crew will recognize storms through prior familiarization with the appearance of cumulonimbus clouds and associated characteristics shapes as viewed from above.

During the mission, the Shuttle astronauts will be radioed meteorlogical information to alert them to possible storm locations based on data gathered by NASA's Marshall Space Flight Center targeting team using the Man Computer Interactive Data Access System located at the Space Sciences Laboratory. This system is a NASA/NOAA sponsored system based at the University of Wisconsin, Madison, which furnished the Marshall team and other research groups with a mix of vast amounts of ground data and satellite weather information.

The second flight on the **Monodisperse Latex Reactor,** a materials processing in space experiment, is designed to test the feasibility of making large size monodisperse (same size) polystyrene latex microspheres using the products of the third Space Shuttle mission as seed particles. The latex spheres are used in calibration of scientific and industrial equipment and have potential medical and research applications.

The experiment consists of four, one-foot-tall reactors, each containing a chemical latex-forming recipe, housed in a two-foot-tall metal cylinder. The recipe is a suspension of very tiny latex beads in water or another liquid. Prior to launch, each of the reactors is loaded with 100 cc's of the chemical latex-forming recipe. A small onboard computer will control the experiment after the Shuttle crew turns it on. In orbit, the latex mixture is heated to a constant 70-degree Centigradewhich initiates a chemical reaction to form the larger plastic beads. A recorder will store all data produced during operation of the experiment. After 20 hours, the experiment will turn itself off.

The latex reactor operated perfectly during the third mission, running for 14 hours and making controlled quantities of beads in sizes up to five microns. On flight four, the experiment will be operated for 20 hours to enhance the capability of making larger monodisperse particles. On Earth, particles can be produced only up to about 3 microns in size and still be monodisperse. This experiment, which is scheduled to be flown on a total of four flights, will help determine if much larger (more than 20 microns) monodisperse spheres can be produced practically and economically in space.

Some of the medical and industrial research applications of the latex beads include measuring the size of pores in the wall of the intestine in cancer research; measuring the size of pores in the human eye in glaucoma research; and as a carrier of drugs and radioactive isotopes for treatment of cancerous tumors. The National Bureau of Standards also has indicated an interest in routine use of the beads as calibration standards in medical and scientific equipment.

Principal investigator on the experiment is Dr. John W. Vanderhoff of Lehigh University. The three co-investigators are Drs. Fortunato J. Micale and Mohamed S. El-Aasser of Lehigh University, and Dale M. Kornfeld of Marshall Space Flight Center.

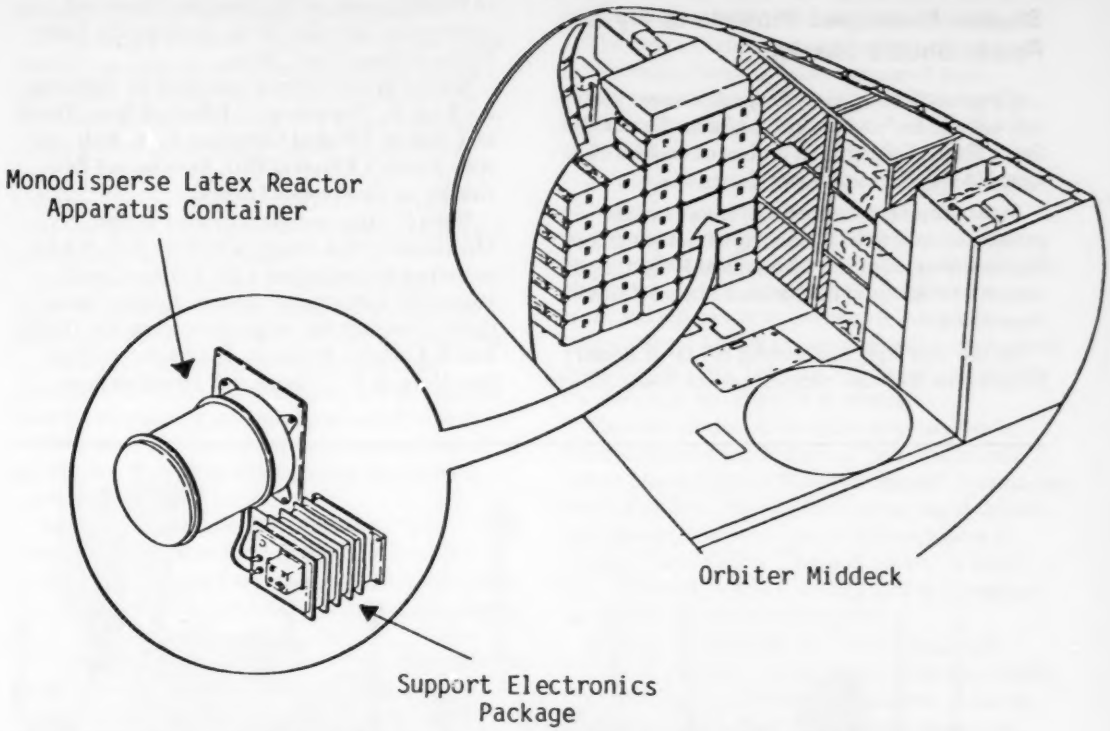


Diagram showing placement of a materials processing in space experiment, the **Monodisperse Latex Reactor,** carried aboard Shuttle Flight Four.

Aboard Columbia for the third mission was the first student-developed experiment, and NASA will continue its **Shuttle Student Involvement Project** on the fourth flight with two additional student experiments from this project slated to fly on Columbia. They are: **Effect of Space Travel on Levels of Trivalent Chromium in the Body,** proposed by **Karla R. Hauersperger,** senior at East Mecklenburg High School, Charlotte, N.C.; and **Effect of Exercise, Diet and Zero Gravity on Lipoprotein Profiles,** proposed by **Amy M. Kusske,** sophomore at Wilson High School, Long Beach, Calif. These two studies involve the physiological effects of space travel on the human body. Neither experiment will require any hardware. Instead, the astronauts will fill out data cards about their exercise periods on the treadmill and their daily food intake. (For more information on these experiments see page 12 of this issue.)

The fourth flight of Columbia is scheduled to last 169 hours with 113 orbits around the Earth. Mattingly and Hartsfield will follow the same course in returning from orbit as did other Shuttle crews: retrofire over the Indian Ocean, atmosphere entry over the western Pacific Ocean, and then a transition to aerodynamic controls in the atmosphere to land as an aircraft.

NASA officials have made the auto land and cross-wind landing highly desirable flight objectives on this flight. Columbia is scheduled to land on runway 17 at Edwards Air Force Base, Calif., a dry lakebed, on Runway 22, a hardsurface runway if acceptable cross-wind conditions are not available. The 3-mile-long paved runway at Kennedy Space Center will be the prime contingency landing site.

Columbia will be guided to its landing site by a microwave scanning beam landing system on the landing site. As the orbiter descends, Mattingly will put the spacecraft through rolls and other maneuvers to test how the spacecraft handles under stress. The vehicle will remain in the automatic mode through touchdown and rollout.

Student-Developed Projects to Fly on Fourth Shuttle Mission

Eleven student-developed experiments are scheduled to be flown aboard the fourth flight of the Space Shuttle Columbia set for launch on June 27 from NASA's Kennedy Space Center, Fla.

Two of these projects are high school student projects selected from 10 winning entries in the first National Shuttle Student Involvement Project, a joint venture of NASA and the National Science Teachers Association.

On the third flight of Columbia in March, another project from this same competition was flown: Effects of Weightlessness on the Honeybee Drone and Velvetbean Caterpillar Moth, developed by Todd Nelson of Rose Creek, Minn.

Student project winners scheduled for flight four are Karla R. Hauersperger's **Effects of Space Travel on Levels of Trivalent Chromium in the Body** and Amy Kusske's **Effects of Diet, Exercise and Zero Gravity on Lipotprotein Profiles.**

Karla R. Hauersperger is a senior at East Mecklenburg High School, Charlotte, N.C. NASA consultant on her project is Dr. Carolyn Leach, Biomedical Laboratories Branch, Johnson Space Center, Houston; her corporate sponsor, Dr. George Van B. Cochran, President, The Explorers Club, New York, N.Y.; assisting with Shuttle payload

Emergency Walk-Through—Shuttle Flight 4 prime crew commander Ken Mattingly (second right) and pilot Henry Hartsfield (far left) do a walk-through of an emergency escape program which might be implemented in the event of a fire at Kennedy's Launch Pad 39A. Launch pad emergency exit basket and slide wire are in background at right.

integration are Chris Perner and John Jackson of Johnson's Crew Station Integration Section.

Hauersperger's research goal is to determine if any alternations occur in chromium metabolism during space flight. As background to her experiment, she presents three known factors: (1) serum levels of insulin are known to change slightly during space flight; (2) insulin helps control body use of carbohydrates; (3) chromium is a cofactor (that is, a substance which must be present in low quantities for an enzyme to work) for insulin.

Her experiment requires a two-part methodology: a record of crew diets from seven days before launch until landing and measurements of crew levels of serum glucose, insulin, chromium and urine chromium. Blood and urine samples will be collected from the crew during scheduled physical examinations on the seventh and second day before launch and on landing day. Blood and urine samples are normally taken on these days.

Analyses of these samples will be done by the Johnson Space Center Biochemical Laboratories and results will be provided to Hauersperger for interpretation. Trivalent chromium will be determined by atomic absorption spectrophotometry.

Amy Kusske is a sophomore at Wilson High School, Long Beach, Calif. NASA consultant and payload integration specialists for her project are the same individuals assisting Karla Hauersperger: Dr. Carolyn Leach, Johnson Space Center, and Chris Perner and John Jackson, respectively, also of Johnson. Kusske's corporate sponsor is William K. Douglas of McDonnell Douglas Astronautics Co., Huntington Beach, Calif.

Kusske's project goal is to determine whether any alterations occur in lipoprotien profiles during space flight. As background to her experiment she presents four key elements: (1) atherosclerosis and coronary artery disease are diseases of epidemic proportions in the United States; (2) people with coronary artery disease are more liable to have heart attacks; (3) several different types of lipoproteins are found in the blood. (The ratio between different types of lipoproteins (particularly high density lipoproteins to low density lipoproteins) can be used to predict the likelihood of someone developing atherosclerosis.); (4) exercise increases the high density lipoprotein/low density lipoprotein ratio, thereby decreasing the risk factor for atherosclerosis and coronary artery disease.

Her project requires a three part methodology: recording crew diets from seven days before launch through landing day; measuring crew lipoprotein profiles, and recording crew physical exercise.

The crew's food content for both experiments will be determined using U.S. Department of Agriculture computerized reference values. During flight, the crew will record on log cards how much they eat of what foods.

As with Karla's experiment, blood samples will be collected from the crew during scheduled physical examinations around seven and two days before launch and on landing day. Analyses of these samples also will be done by Johnson's Biochemical Laboratories and results will be provided to Amy for interpretation. Lipoprotein profiles will be determined by electrophoresis. The crew will record on log cards the time, type and duration of exercise.

The other student-developed experiments to be flown aboard the fourth flight of Columbia in June will be placed within a **"Getaway Special"** 5-cubic-foot payload canister. This payload, consisting of the nine experiments, was purchased by Gilbert Moore of Thiokol Corp., Ogden, Utah and donated to Utah State University where it is being used as a program for student-developed experiments.

Getaway Specials, officially titled "Small Self-Contained Payloads," is a program offered by NASA to provide an opportunity to anyone who wishes to fly a scientific or technological project aboard the Space Shuttle. The canisters come in three sizes with the flight fees varying per size: 5 cubic foot, maximum weight of 200 pounds; 2½ cubic foot, up to 100 lbs., and 2½ cubic foot, up to 60 lbs. Prices are $10,000, $5,000 and $3,000 respectively. There are no stringent requirements to qualify for space flight but the payload must meet certain safety criteria.

Getaway Specials are flown on Shuttle missions on a space available basis. Since the offer for Shuttle space was first made in 1976, more than 376 reservations have been made by more than 197 individuals and groups from 33 states, the District of Columbia and 14 foreign nations.

The following nine Utah State experiments scheduled for flight four represent the first private sector payload to be flown as a Getaway Special.

Drosophilia Melanogaster (Fruit Fly) Growth Experiment. Student Investigator: Walt L. Moore, HDR Sciences Co., Santa Barbara, Calif., graduate student/environmental sciences.

This experiment is designed to provide a means of raising and separating succeeding generations of fruit flies in orbit to study the effects of micro-gravity

on their genetic structure. This will be a test of equipment that is proposed to be flown on the Long Duration Exposure Facility, scheduled for launch in 1984.

Artemia (Brine Shrimp) Growth Experiment. Student Investigator: Bruce W. Moore, Weber State College, Ogden, freshman/music major.

The brine shrimp Artemia will be flown to determine the genetic effects of micro-gravity on cysts hatched in space. Cysts will be injected into a saline solution upon experiment activation. The growing shrimp, called nauplii, will be observed during the remainder of the flight with a 35-mm motordriven Nikon camera with a 55-mm micro-Nikkor lens. The camera will be shared between this experiment and another experiment concerning observations of Duckeed growth in micro-gravity. Powdered rice hulls will be fed to the shrimp by a linear actuator. The shrimp will be studied post-flight by means of electron microscopy.

Surface Tension Experiment. Student Investigator: James Elwell, Utah State University, Ogden, graduate student/electrical engineering.

The goal is to study the shape of a liquid meniscus in a weightless environment. An aluminum block contains several holes filled with solder. Upon entering weightlessness, the block is heated, allowing the solder to flow and assume a meniscus (crescent-like) shape. The block is allowed to cool, "freezing" the meniscus when the solder solidifies.

Composite Curing Experiment. Student Investigator: Amber M. Dalley, Utah State University, Ogden, senior/math-philosophy major.

This experiment will complete the cure of a B-staged (partially cured) epoxy resin-graphite composite sample in microgravity. The composite sample will be heated to 163 degrees C and maintained at that temperature for one-half hour to allow the resin to gel. The flight sample will be compared with samples processed in one g, and post-flight laboratory analysis will determine the quality of wetting between the resin and the graphite fibers and test the tensile strength of the sample.

Thermal Conductivity Experiment. Student Investigator: Russel R. Laher, Utah State University, Ogden, junior/physics-geology major.

An oil and water mixture in a one g environment will separate due to the density difference. The goal of the experiment is to carry oil and water into orbit and mix the two, then heat the mixture with a platinum wire. Temperatures of the heater wire, the mixture, and the air around the cylinder will be monitored. Ultimately, the thermal conductivity of the mixture will be calculated from these data.

Micro-Gravity Soldering Experiment. Student Investigator: G. Christian Alford, Utah State University, Ogden, senior/electrical engineering major.

The Micro-Gravity Soldering Experiment studies the separation of flux from solder while soldering in weightlessness. The lack of buoyancy in a non-accelerating environment could allow pockets of flux to become trapped in the solder. The experiment will melt samples of resin core and coreless solder on four heated copper foils. When the experiment is returned, the solder will be analyzed for trapped pockets of flux and compared with solder similarly processed on Earth.

Root Growth of Lemna Minor L. (Duckweed) in Micro-Gravity. Student Investigator: Kelly D. Hunt, Utah State University, Ogden, junior/physics major.

Using the 35-mm Nikon, shared with the brine shrimp experiment described earlier, this experiment will photograph the root growth patterns of Lemna Minor L. (Duckweed). The investigation centers on the nutrient transport role played by sieve tubes in the plants' roots in response to the force of gravity in Earth-grown specimens. The plants will be injected with a fixing agent before experiment deactivation. Electron microscopy will be used to compare control and flight specimens.

Homogeneous Alloy Experiment. Student Investigator: Terrance L. Thomas, Utah State University, Ogden, junior/electrical engineering.

An aluminum chamber containing a powdered bismuth-tin mixture will be placed into Earth orbit. The chamber will be heated, passing the melting points of the chemicals and allowing formation of an alloy to take place. The chamber will cool down and the alloy will be returned for Earth-based analysis.

Algal Micro-Gravity Bioassay Experiment. Student Investigator: Steven M. Walker, Utah State University, Ogden, senior/biology major.

The goal of the experiment is to monitor the growth rate of Chlorella vulgaris, a unicellular green algae, in micro-gravity. Upon experiment activation, a freeze-dried sample of algae will be injected into the media-filled growth chamber. Over the duration of the experiment the culture optical density and temperature will be measured. Near the end of this experiment, a fixative will be injected into the chamber preserving the cells for post-flight analysis.

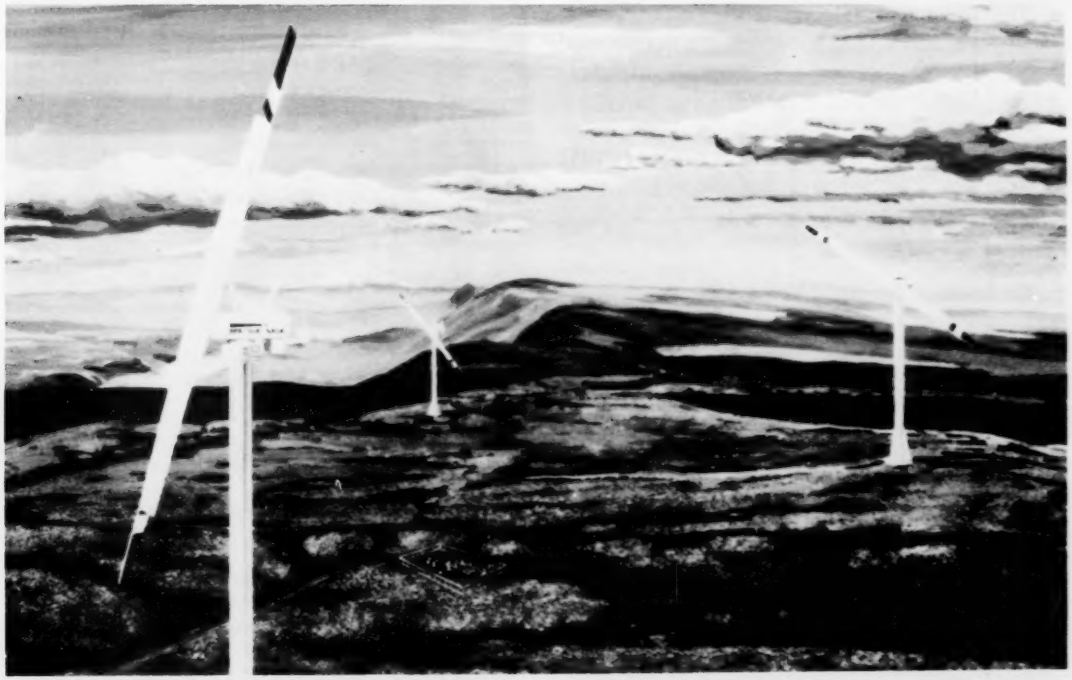
Nation's First Large Wind Turbine Cluster in Full Operation

Three of the world's largest wind turbines are now working together for the first time in the nation's only multi-megawatt wind turbine cluster. The Mod-2 wind turbines, located at Goodnoe Hills, Wash., together will generate enough electricity to serve approximately 2,000 average homes. Each turbine is rated at 2,500 kw. This cluster of wind turbines are currently the most advanced in a series of experimental horizontal-axis machines developed in a program sponsored by the Department of Energy and managed by NASA's Lewis Research Center, Cleveland.

The three machines were dedicated in May 1981. Unit No. 1, however, had been shut down since last summer when a failure occurred in the control system during a simulated emergency shutdown test of the machine causing damage to its electrical generator and power train. The nation's largest multi-megawatt wind farm now is back in full cluster operation. Testing and research investigations are underway in the areas of aerodynamics, structural dynamics, materials and multiple systems interactions.

Each wind turbine stands 61 meters (200 feet) above the ground (hub height), with the rotor blades measuring 91 m (300 feet)—the length of a football field—from tip to tip. The Mod-2s are designed to begin producing power in winds of 23 kilometers per hour (14 miles per hour)—measured at the machine's hub height—and reach rated power output in winds of 45 km/hr (28 mph). When wind speeds exceed 72 km/hr (45 mph), the blade tips automatically feather, shutting down the system. Winds at the Goodnoe Hills site average 27 km/hr (16½ mph) and blow between 23 and 72 km/hr (14 and 45 mph) about 60 percent of the time.

The second generation Mod-2s were built on a technology base developed by research and testing on smaller first generation wind turbines. Tests on the four 200 kW, Mod-OA wind turbines located in New Mexico, Puerto Rico, Rhode Island and Hawaii are now nearing completion. The Mod-OA wind turbines were designed to obtain early operation and performance data while gaining initial operating



Artist concept of the world's largest wind turbine cluster in Goodnoe Hills, Wash., which together generate enough electricityto service 2,000 average homes.

experience in existing utility systems. Since the first installation in 1977, these machines have accumulated more than 36,000 hours of operation, and generated more than 3,500,000 kWh of energy.

In addition, a scaled-up machine similar to the Mod-OA, designated as the Mod-1 2,000 kW wind turbine, located in Boone, N.C., demonstrated that electric power produced by a megawatt-size wind turbine could be successfully fed into a utility grid, and verified the design approach used on large wind turbines. These early machines were experimental and not expected to be cost effective. However, their operating experience and performance characteristics have had a significant effect on the design of the second generation Mod-2 machines developed under the Federal Wind Energy Program.

The Mod-2 wind turbines were designed, manufactured and erected by the Boeing Engineering and Construction Co., Seattle. The Bonneville Power Administration provided the site and constructed the substation and power system facilities. Bonneville also will take power from the experimental turbines and feed it into the northwest power grid for use by regional utilities.

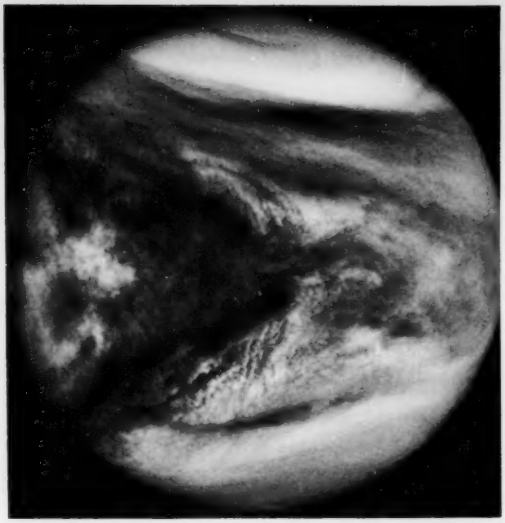
The Department of Energy, through national laboratories and NASA, is continuing to support wind energy research to develop a technology base for a growing wind industry.

Scientific Evidence Reveals Venus Had Oceans

The searingly hot planet Venus at one time had sufficient water to have possibly had oceans 30 percent or more the size of Earth's oceans, concludes University of Michigan atmospheric scientist, Dr. Thomas M. Donahue. Donahue, one of NASA's Pioneer Venus interdisciplinary scientists, and colleagues have pieced together data obtained during the descent of the Pioneer Venus Large Probe into the yellow planet's lower atmosphere which supports this theory.

The port to the large probe's mass spectrometer became coated with sulfuric acid droplets from Venus' clouds and reliable measurements were not expected to result while the port was clogged.

Donahue and fellow investigators believed analysis of the sulfuric acid blocking the instrument port could contain sufficient traces of Venus water to permit determination of the current ratio of deuterium (heavy hydrogen) to hydrogen. Because of the different rates of escape of light hydrogen (H) and heavy hydrogen (D) over geologic time, determination of the current deuterium/hydrogen ratio would provide the atmospheric scientists with indications of whether Venus has always lacked water or whether large amounts of water were present early in the planet's evolution but were subsequently lost.



Recent view of Venus taken by the Pioneer spacecraft in orbit around the planet until 1986.

Based on their data analysis of the probe's sulfuric acid droplets, Donahue and his colleagues postulate that the present ratio of deuterium to hydrogen on Venus is on the order of 1.6 x 10 (to minus 2 power). This current ratio coupled with additional estimates of the original ratio of deuterium to hydrogen on Venus—estimated to be close to that originally on Earth, or 1.5 x 10 (to minus 4 power)—have led Donahue and colleagues to suggest that originally Venus had an ocean which was lost as a result of hydrodynamic outflowing of hydrogen.

Following a large initial outgassing of water from the planet, Donahue suggests that a runaway greenhouse condition ensued which drove hydrogen from the liquid ocean into the atmosphere from which it subsequently left through supersonic hydrodynamic escape. Since this process favors the escape of hydrogen, the deuterium found in the Venus atmosphere today is an observable remnant of the early Venus ocean.

Donahue and his colleagues suggest the minimum amount of water lost from Venus was the equivalent of one third of Earth's oceans, although it could have been more.

These findings present intriguing possibilities for future exploration of the cloud-shrouded planet. NASA is currently studying a radar mapping mission to Venus which could provide topographical evidence of early river channels and oceans.

Wind Tunnel Testing at Langley—At left a new radical wing design undergoes wind tunnel testing at NASA's Langley Research Center, Hampton, Va. This one-sixth scale model of the experimental X-29A is the subject of a research program managed by the Defense Advanced Research Projects Agency. The model is flown by remote control to study low-speed stability and control characteristics. Compressed air, supplied by an attached hose and computer and other control tests allow engineer pilots to simulate actual scaled flight. Findings from Langley's testing are helping to develop the full-scale prototype model by Grumman Aerospace Corp., scheduled for flight tests in 1984.

Spacelab Experiment Installation Begun

Installation of experiments on the Spacelab 1 pallet has begun at NASA's Kennedy Space Center, Fla., in preparation for the first flight of the reusable scientific laboratory in September 1983.

Spacelab, a versatile, on-orbit research facility developed for NASA by the European Space Agency (ESA), and funded by its member states, will be carried in the cargo bay of the Space Shuttle orbiter. Configuration for the first flight, a joint NASA/ESA sponsored mission, will consist of a habitable module in which scientists will work, and a pallet which will support experiments requiring direct exposure to space.

NASA's Marshall Space Flight Center, Huntsville, Ala., is responsible for monitoring the laboratory's development and for managing the first three missions. Actual installation of experiments and preparation of the laboratory for launch is being done at Kennedy.

Thus far all structural attach points have been installed on the pallet and installation has begun of the high voltage power supply for the Space Experiments with Particle Accelerators (SEPAC) payload. This payload is a Marshall sponsored experiment series that will study interactions of the Earth's magnetosphere and upper atmosphere.

Following installation of the power supply, the orthogrid, a table-like structure that will hold NASA-sponsored pallet-mounted experiment hardware, will be attached.

In addition to the pallet integration work, Space Center workers are continuing to install experiments in the laboratory racks that will be carried inside the habitable module. Once integrated, the racks will be hooked together and slipped into the module as a unit. NASA's Johnson Space Center, Houston, Life Sciences Mini-lab, a double rack of biology experiments, has been transferred from its ground test to its flight rack, and has been checked out. Three other racks are presently being integrated. One will contain control and display panels for SEPAC, Atmospheric Emission Photometric Imaging and Imaging Spectrometric Observatory hardware.

The first two are space plasma physics experiments and the third is an investigation in the field of atmospheric physics and Earth observations. Another rack will hold a data display unit, video instrumentation recorder, and a package of tribiological experiments which will study lubrication in zero gravity. The third rack will contain storage compartments.

Space Techniques Separate Paintings Hidden Beneath Master Works

Space scientists at NASA's Jet Propulsion Laboratory, Pasadena, Calif., working with art conservators at the Los Angeles County Museum of Art, have developed a new technique for separating paintings hidden beneath master works. The effort resulted in the first successful use of image enhancement techniques to separate X-ray images of paintings where two or more works exist on the same surface.

The technique, derived from computer-processing of photographs from NASA's unmanned spacecraft, will allow art conservators and museum curators to better evaluate earlier compositions often found underneath easel paintings.

William R. Leisher, head of conservation at the Los Angeles County Museum of Art, asked NASA's Jet Propulsion Laboratory investigators to separate and enhance a painting found to exist beneath the 17th century oil painting "The Crucifixion," by an unidentified Flemish painter.

Astronomer Dave Glackin and scientist Don Lynn, both image processing specialists, and computer analyst Raim Quiros, in collaboration with Jim Druzik and Dr. Pieter Meyers of the museum, developed computer programs for subtracting the top painting from the bottom, so that the hidden painting may be seen in detail.

"The Crucifixion," painted on paper, shows Jesus Christ being lowered from the cross by a group of followers. The bottom painting, directly on the 16 by 24-inch wooden panel, shows a scene of a man and a woman seated at a table. The two are dressed in 17th century clothing, and the room is lighted by sunlight shining through a window.

Art conservators commonly use X-ray photography to examine paintings. The X-ray photos may often show that paintings or sketches exist beneath a top painting, but the works are not automatically delineated. The two works usually are fused in an X-ray photo and appear as a blurred, double image.

"What we sometimes find is a completely different composition underneath," said Druzik, associate conservator at the museum. When that happens, he said, "there will always be a question in the curator's mind as to whether or not an unknown masterpiece exists under the top painting layer."

The Crucifixion, a 17th century oil painting by an unknown Flemish artist was painted over another completely different work as revealed through X-radiographic photography and computer processing completed by NASA's Jet Propulsion Laboratory and the Los Angeles County Museum of Art. The new image separation technique was developed from computer processing photgraphs from NASA's unmanned spacecraft. Painting at top shows Jesus Christ being lowered from the cross; beneath this work is the painting revealed in the bottom image: two figures in 17th century clothing seated at a table.

In order to separate the two images, NASA's Jet Propulsion Laboratory team first designed computer programs to minimize the appearance of the grain patterns of the wood on which the original work was painted. Next, a photograph of the top painting was matched with the X-ray image. Any brush strokes from the X-ray version that matched the top painting were subtracted. Consequent subtractions removed most traces of the top painting, while the remaining was computer-enhanced to bring out detail.

The pioneering development of the painting subtraction technique could lead to future systems designed uniquely for discerning and separating multiple X-ray images of paintings with designs under the surface. Such systems, said Druzik, "will be another invaluable tool for conservators and curators."

"This project is a good example of the applications of space technology to other problems of great public interest," said Dave Glackin. Glackin and Kurt Liewer, both of NASA's Jet Propulsion Laboratory, working with museum conservators, are undertaking a new task: using a high-resolution spacecraft photography system and the laboratory's image processing facility to study the condition of the museum's "Codex Hammer" by Leonardo da Vinci. Results from the project, supported by a grant from the Armand Hammer Foundation, should determine how to best preserve the works.

Future applications of computer processing to art conservation might include techniques to date paintings by determining the age of wood on which compositions were painted. Dendrochronology, the science of dating wood based on the number and character of tree rings, usually requires shaving wood away from the edge of the original wood panel. Computer enhancement of the wood grain of a panel would eliminate the need to remove original support material in order to date it.

The $35,000 painting subtraction project was funded by Caltech President's Fund. NASA's Jet Propulsion Laboratory, Pasadena, is operated for NASA by the California Institute of Technology.

Electric Rocket Engine Completes 11 Years in Space

An 11-year space journey by SERT II has proven that solar-powered, ion-electric rocket engines are an efficient and reliable new type of space propulsion. SERT II (for Space Electric Rocket Test II) is the second in a series of these experimental engines to be developed and built at NASA's Lewis Research Center, Cleveland.

Launched Feb. 4, 1970 from Cleveland, SERT II had traveled 1.6 billion miles and had circled the Earth 56,143 times when contact between it and the ground was cut off on June 5, 1981. This rocket engine operated for some 100,000 hours during its lengthy space journey, executed more than 6,000 commands sent up from the Lewis ground station, and transmitted 5 billion bits of information over a period of 40,000 hours. Much useful information on the long-term operation of thruster components, power supplies and solar arrays also was obtained.

In its long flight, SERT II traveled in a circular polar orbit in which the vehicle passed over both the North and South poles, allowing it to remain in total sunlight during a complete orbit.

The ion robot propulsion system is expected to be used for energetic missions including comet and asteroid rendezvous, exploration of the outer planets, as well as for Earth-orbital applications such as station-keeping of communications satellites and orbital platforms.

The SERT II type propulsion system differs from the more familiar Space Shuttle chemical propulsion systems. The Shuttle engines develop tremendous thrusts by releasing the energy stored in chemical reactions. The electric rocket engine is called an ion thruster because the thrust of the engine is produced through the rapid, controlled discharge of ions created by the ionization of atoms of the fuel supply. Though several elements make efficient fuels, the SERT II program used liquid mercury. In operation, solar cells convert sunlight into electricity which is then converted from 80 v. dc in the power conditioning unit. With this electric power, mercury atoms are bombarded with free electrons, which knocks one electron off each mercury atom to produce what is called ionized mercury; that is, positively charged mercury atoms. Thus electrified, the ions mix with other electrons to form a plasma, which is a group of very hot gases capable of conducting electricity.

A magnetic field set up between two metal screens at the aft end of the engine draws the positively charged ions from the plasma and accelerates them at very high exit speeds out of the engine. This creates a high velocity ion beam for efficient thrust. Electrons are injected into this beam, producing a neutralized gas that subsequently drifts out harmlessly into space. While the ion rocket engine thrust level is much less than chemical rockets it can provide years of

low level thrust.

SERT II weighed 1,500 kilograms (3,300 pounds). Its main body was 6 meters (20 feet) long and 1.5 m (5 ft. in diameter, and two 15-cm (5.9 in.) diameter electric rocket engines were positioned at one end of the craft. At the other end, two 7.6-m (25-ft.)-long by 1.5-m (5-ft.)-wide solar cell arrays were spread to capture and convert sunlight into the electricity needed to operate the experimental engines and other onboard equipment.

The next space test of an ion rocket engine will take place in 1983. Two small ion rocket engines, each 8-cm (3-in.) diameter, will be tested for more than two years in space. These engines, called IAPS for Ion Auxiliary Propulsion System, were designed by Lewis engineers and are built by the Hughes Research Laboratories. If the engines test successfully, they will be used on communications satellites to greatly increase their lifetime.

More powerful versions of the ion rocket engine, 30-cm (11.8 in.) in diameter, have received much Earthbound testing while the SERT II engines were being tested in space. Designs for engines were turned over to NASA's Marshall Space Flight Center, Huntsville, Ala., for use as the main, in-space propulsion for spacecraft. Funding limitations have prevented the actual use of these large engines, but they hold great promise to become the space propulsion rocket system of the future.

Invented and first demonstrated at the Lewis Center in 1958 by Dr. Harold R. Kaufman, the first mercury-fueled electric rocket engine was proved feasible in a SERT I ballistic space flight that lasted only 50 minutes. That brief flight proved that mercury-produced ion beams could be successfully neutralized in space. In the following years, engineers worked to improve and retune the engine's technology.

Chocolate Tribute to Shuttle Flight 3—Chocolatier Marcel Antoine and wife Suzanne, of Hackettstown, N.J., honored the third flight of Columbia in their own unique way—by sculpting a 75-lb. chocolate replica of the spacecraft. Chocolate Columbia was the focus of Marcel's 19th annual Easter confectionery display at his candy shop in Hackettstown. Measuring 47 inches tall and 33 inches wide, Marcel perched 5-inch tall candy figures of astronauts Lousma and Fullerton on ladders inside the cargo bay which was bedecked with American flags and miniature Easter chickens and eggs for companions. The chocolate Shuttle was melted down soon after Easter.

Upper Stage Rocket Begins Checkout at KSC

With the first operational flight of the Space Shuttle imminent, one of the major elements to be used in the operational phase has begun checkout at Kennedy Space Center.

The Inertial Upper Stage (IUS) pathfinder vehicle began fit testing and electrical checkout at KSC in April. The inert stage substitutes for an actual transfer vehicle designed to boost heavy payloads from low earth orbit to operating altitudes.

Checkout includes installing the pathfinder vehicle in the payload canister, or portable white room, which will move the IUS/satellite combinations from assembly and processing facilities to the launch pad, and handling tests within the Payload Changeout Room at the pad.

Using a pair of solid rocket motors, the stage will be capable of boosting satellites weighing more than 2,000 kilograms (4,409 pounds) into geosynchronous orbit. The rocket motors can be tailored to specific power levels to custom-fit the IUS to particular mission requirements.

Unlike the single-stage Payload Assist Module (PAM) used for lighter payloads, the IUS is not spin stabilized. An inertial guidance system in the IUS allows bulky, non-spinnable payloads to be boosted while retaining the simplicity and reliability of solid rocket design.

The design concept allows IUS to do double duty by being usable aboard the Space Shuttle as well as the Air Force's uprated Titan 34-D expendable rocket. Similarly, the PAM can be used with Space Shuttle or aboard NASA's veteran Delta booster.

The first actual use of the IUS aboard the Space Shuttle is planned to be during STS-6 (also the maiden flight of the orbiter Challenger), and the payload will be the first of two Tracking and Data Relay Satellites (TDRS). Future uses will include the second TDRS spacecraft, heavy satellites of the INTELSAT class, with possible uses with Department of Defense payloads and planned interplanetary probes such as the Galileo mission to Jupiter under discussion.

The Space Division of the Air Force Systems Command, developer of the IUS, has awarded a contract to Boeing Aerospace Company for construction of nine IUS flight vehicles to be used during the 1980s.

Inspector General Activities

NASA's Office of the Inspector General and the FBI have signed a Memorandum of Understanding that acknowledges the role of the FBI in investigating criminal violations of Federal law, and the statutory mandate of the Inspector General to investigate and report on matters which involve the programs and operations of NASA. The memorandum provides that the FBI and NASA's Office of the Inspector General will cooperate on investigations of criminal activities which involve NASA programs and functions. The Office of the Inspector General will direct efforts at the detection and prevention of fraud, waste and inefficiency, and conduct, supervise and coordinate Inspector General audits and investigations relating to the programs and operations of NASA. The FBI will retain investigative jurisdiction in matters consisting of bribery, attempted bribery, or other corruption which culpably involve U.S. Government employees.

Four NASA employees received oral and written reprimands as a result of an investigation conducted by the Office of the Inspector General. The investigation was initiated following a lead provided by a NASA employee alleging violation of procurement practices. Results of the investigation revealed that NASA's sole-source procurement practice was being violated by several employees who had falsely certified documents with the intent of shortcutting the procurement process.

They've Got the Whole Shuttle in Their Hands

On June 27 NASA is scheduled to launch the Space Shuttle Columbia for the fourth time from launch pad 39A at Kennedy Space Center, Fla. Part of the enormous job of readying the orbiter for a new mission requires vertically lifting the vehicle once inside Kennedy's Vehicle Assembly Buliding (VAB) where it is mated with the External Tank and twin Solid Rocket Booster assembly.

Such a task rests with two employees of a 32-member Boeing Services International (BSI) crew which has the job of running cranes used to lift and transport Space Shuttle flight hardware around the Spaceport's facilities. For an inside look at what it is like to have America's manned space program literally in one's hands, we turn to BSI crew members Dave Earhart and Tom Shinholster.

Boeing Services International crane operators Tom Shinholster (left) and Dave Earhart man the controls of the 250-ton crane used to lift the Shuttle orbiter for mating with the solid rocket boosters and external tank.

As they explain, operating cranes are only a part of the crews' work but without doubt is the most challenging task they face. "You do, at some point or another, have every part of the flight hardware in your hands," says Earhart who was at the controls when Columbia was lifted above the VAB's transfer aisle and over into High Bay 3 prior to the first two Shuttle launches.

Earhart has been on this job for two years and describes his work as exciting, rewarding, exhausting and sometimes a little nervewracking. He quickly notes that when he looks out the window of the crane's cab and sees Columbia suspended 300 feet below (the length of a football field) he has a single overpowering thought—"To do the very best job I can."

Tom Shinholster is a Kennedy Space Center veteran. He joined the crew 15 years ago, after working on a construction crane during the building of Kennedy Space Center facilities.

He also was involved in hoisting the Shuttle orbiter during preparation for the first two missions. While most people would be thrilled to just get a glimpse of the Columbia, Shinholster says that handling something even as unique as America's new manned spacecraft becomes basically routine. He's quick to point out that those whose fingertips control the lifting of the 100-ton spaceship depend on other crew members. The guy on the ground paints the picture for you," he explained.

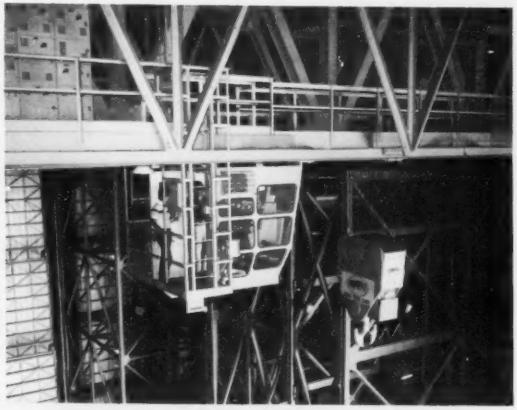
Sitting 468 feet above the VAB floor, Shinholster points out, is hardly an ideal vantage point for eyeballing the movement of the orbiter which must pass by some structures with a clearance of only a few inches. When the Columbia is lowered into position for mating with the solid rocket boosters and external tank, the alignment must be precise.

"There's no margin for error," says BSI supervisor Wayne Crawford, who handled the cranes back in the days when it was Saturn V segments and Apollo command modules being hoisted about the Vehicle Assembly Building. Crawford uses a crew of about a dozen technicians for the orbiter hoist operation.

Two persons operate the crane from the overhead cab and the rest take positions on the ground and selected levels to provide guidance to those with their hands on the control sticks.

Sitting in the left-hand seat of the cab, Shinholster demonstrates how he moves the crane and its loads forward, backward, and sideways. He grips a hand lever, which resembles the floor gear-shifter in a standard transmission car, and eases it to the left. A motor begins to whine and the VAB floor seemed to move westward. "What you do is start off real slow and just increase it," he explains. "You don't make any sudden stops."

In the right-hand seat, Earhart occupies the position of the crewman in charge of raising and lowering the load, and communicating with other members of the team. "The thing that amazes me about this equipment is that you can take a 250-ton load and move it in just about any direction as little as 1/128th of an inch," said Earhart.

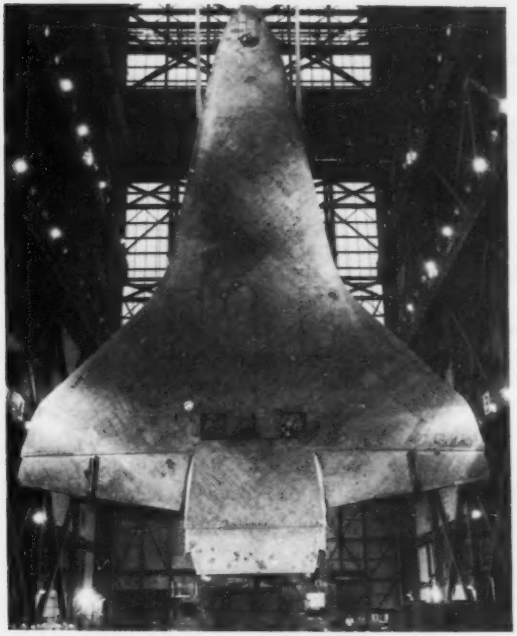


Crane used to hoist the Shuttle orbiter for mating with the external tank and solid rocket boosters is operated by Boeing Services International crews from a cab which sits 468 feet above the Vehicle Assembly Building floor.

He gently grasps the hand control and fixes his eyes on a small dial marked in increments of 1/64th of an inch. The needle slowly moves midway between two marks . . . and stops.

"It's like driving your car," says Crawford. "You have to know what you're doing."

In addition to lifting the Space Shuttle in the Vehicle Assembly Building, Crawford's BSI crew operates cranes in the Orbiter Processing Facility, at the pad, and at the Shuttle landing facility. They lift all other Shuttle hardware as well and are responsible for moving work platforms, and for opening the VAB doors when it is time for the Space Shuttle to roll out to the launch pad.



The pinnacle of their labor reached, Space Shuttle Columbia is suspended by the 250-ton crane in Kennedy's Vehicle Assembly Building manned by Boeing Services International operators Tom Shinholster and Dave Earhart. The three points where the orbiter attaches to the external tank are prominent in this view.

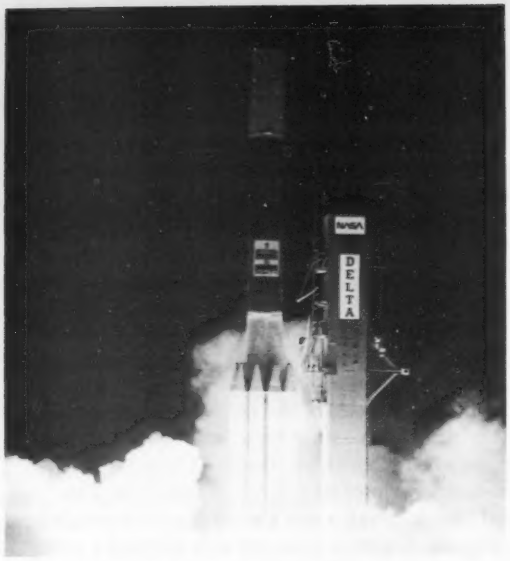
Contractor News

NASA's Marshall Space Flight Center, Huntsville, Ala., has selected **Hercules Inc.,** and **Votaw, Precision Tool, Inc.,** Magna, Utah, a joint venture, for negotiation under the Space Shuttle solid rocket booster contract for the development of a filament wound case configuration for the solid rocket motor used in the Space Shuttle's solid rocket boosters. The filament wound case subcontract will be a cost plus incentive/award fee type for design, development, test and delivery of four flight cases for a proposed cost of approximately $33 million. The filament wound case segments will replace portions of the current steel case segments for high performance launches. The performance increase is achieved by a reduction in the Shuttle liftoff weight of approximately 29,937 kilograms (66,000 pounds) from the baseline steel case motors. The first use of the wound case motors is expected late in 1985.

Perkin-Elmer Corp., Optical Group, Danbury, Conn. has been selected by NASA for negotiation of a final definition contract for a Solar Optical Telescope which, when successfully completed, could lead to a full-scale development contract in mid-1984. This final selection, with a split contract period scheduled to begin in August, is in accord with the NASA policy not to commit to full scale hardware development until all technical issues have been resolved and a final cost has been established which will provide a reasonable basis for completion of the work within the agreed upon schedule. The contractor's proposed cost for the entire effort including options is approximately $57 million. The Solar Optical Telescope will take measurements over the visible and much of the ultraviolet wavelength range of the Sun using a Gregorian telescope system with extremely fine resolution. The observatory is designed to provide a major step forward in the scientific study of solar physics by getting above the resolution limit imposed by Earth's atmosphere.

NASA's Kennedy Space Center has awarded a $7.2 million contract to **W&J Construction Co.,** Cocoa, Fla., to construct a complex of new buildings to process and store solid rocket booster segments. Under the terms of the fixed-price contract, W&J will provide the labor, equipment and materials to construct the Solid Rocket Booster Rotation/Processing Facility and two booster segment storage buildings. The award was made to a small business firm. Construction of the facilities is to take about 18 months. When complete, these facilities will enable Kennedy to store two sets of solid rocket boosters and to support more than 20 launches a year.

Ford Motor Co.'s Scientific Research Laboratories, Dearborn, Mich., has been awarded a $6.8-million contract by NASA's Lewis Research Center, Cleveland, to develop the technology for an advanced



Successful Deltas—Two recent successful launches of communications satellites using Delta expendable vehicles. Top photo is INSAT-1, an Indian communications satellite launched April 10 from the Eastern Space and Missile Center, Fla.; bottom photo is WESTAR-V, a Western Union communications satellite launched June 8 also from Eastern Space and Missile Center.

powertrain that could be used in future electric cars. Specific goal of the three-year contract is to establish and verify critical technologies associated with developing a lightweight, low-cost and highly efficient powertrain. An improved powertrain is a key to significantly enhancing the near-term possibility of an affordable electric vehicle. Under the contract, an experimental, proof-of-concept powertrain will be built. This powertrain, as conceived by Ford, would consist of a unique and innovative integral, concentric ac motor/automatic transaxle, an inverter/motor controller and a vehicle controller. The motor differential and a two-speed automatic shift transmission would be integrated into a single unit. By integrating such functions, cost, size and weight of the unit would be considerably lower than if each were to be separated. **Ford will subcontract** a large portion of the electrical subsystem work to **General Electric Co.'s Research and Development Center,** Schenectady, N.Y. G.E. will develop technology for the motor, inverter and motor controller and conduct laboratory tests on the complete powertrain. Ford will be responsible for the overall system technology, the research and development for the transaxle, fabrication of the vehicle test bed and the powertrain tests.

NASA's Johnson Space Center, Houston, has awarded a letter contract to **Rockwell International's Space Operations/Integration and Satellite Systems** Div., Downey, Calif., covering integration of the OSTA-3 (Office of Space and Terrestrial Applications) payload into Shuttle orbiter Columbia. Initial value of the letter contract is $370,000 and the total amount of the definitive cost-plus fixed fee contract is $3,772,000.

Rockwell will assemble a special pallet or an orbital flight pallet and integrate onto the pallet OSTA-3 scientific instruments and support subsystems. The contract will also cover payload staging, preflight checkout and postflight operations at NASA Kennedy Space Center. The OSTA-3 payload is currently scheduled to fly aboard Columbia on flight 16, June 1984.

International Business Machines Corp., Cape Canaveral, Fla., has been awarded a $1,558,420 contract modification by NASA's Kennedy Space Center for additional services under an existing contract. IBM is presently under a three-year contract extension with Kennedy for systems engineering and software development services in support of the Launch Processing System used at the Spaceport for automated checkout and launch of Space Shuttle vehicles. This award, for additional work under that existing

contract, brings the total value of the contract to $85,913,954. The cost-plus-award-fee contract modification covers the period from Jan. 19, 1982 through Sept. 30, 1984.

NASA has selected **American Airlines' Flight Academy,** Ft. Worth, Texas, for contract negotiations for installation of a new helicopter simulator system caled Advanced Cab and Visual System at Ames Research Center, Mountain View, Calif. The system will be funded by the U.S. Army and will be used jointly by the Army and NASA. The system is designed to duplicate helicopter cockpit configurations and flight handling characteristics. The complex will provide a systems approach to rotorcraft design and a simulation capability to support handling quality experiments, flight tests, product improvement evaluations and basic rotorcraft technology. The proposal was for approximately $16 million. Pilots and engineers will use the new system to simulate the total handling characteristics of helicopter flight, including sight, motion and sound. The system can be run as a stationary installation or can use the Vertical Motion Simulator Facility to generate large motions.

Wackenhut Services, Coral Gables, Fla., has been awarded a $9.6 million supplemental contract by NASA's Kennedy Space Center for security and fire protection services. The cost-plus-fixed-fee contract supplement carries a dollar value of $9,628,389, bringing the total value of the Wackenhut contract at Kennedy to $48,980,083. The supplement covers the period from when the contract was awarded on April 1, 1982, through October 31, 1982.

Grit and Determination—These two elements clearly displayed on the face of astronaut Sally Ride as she underwent water survival training as an astronaut candidate. Part of what is termed a "drop and drag phase," students are dropped from the rear of a moving boat and then must release themselves from a parachute harness while being dragged on the stomach and back. Ride, the first woman astronaut to go into space, is scheduled for the seventh Space Shuttle mission in April 1983.

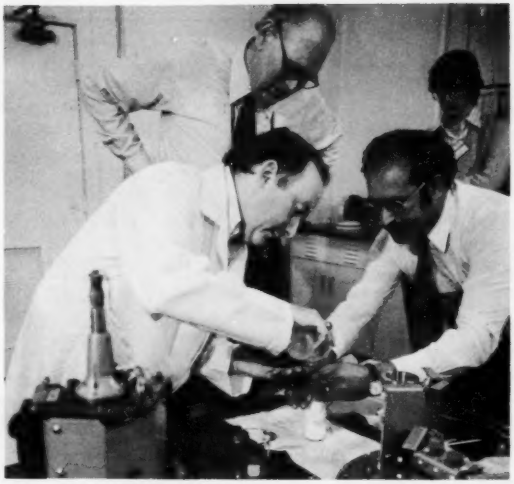
NASA's Marshall Space Flight Center, Huntsville, Ala., has awarded twin $1 million contracts to two optical companies to build precision mirrors representative of those to be flown on NASA's Advanced X-Ray Astrophysics Facility, or "AXAF," an orbiting X-ray observatory proposed for launch later in the decade. The double contract award assigns responsibility for parallel but independent work toward the building of these test mirrors, not intended to be flown in space to **ITEK Corp.,** Lexington, Mass., and to **Perkin-Elmer Corp.,** Danbury, Conn. Each of the contracts is two years in duration. At the end of the contract period, the two companies will be expected to present their individual approaches to the grinding and polishing of the actual mirror which will be built for the observatory in the late 1980s. The test mirrors will be smaller than the mirror to be flown in space. The test mirrors will allow NASA to evaluate the ability of these contractors to achieve the level of performance necessary. A greater precision than previously achieved in X-ray optical systems is sought. Proposed for launch in 1989 or 1990, the observatory would be technologically superior to any X-ray facility previously sent into space. Weighing 100,000 kilograms (11 tons) and measuring 4.2 by 13 meters (14 by 43 feet) it would be carried by the Space Shuttle and placed in an orbit 485 kilometers (300 miles) above the Earth for operation over a lifetime of about 15 years. The observatory is expected to view X-ray sources toward the very edge of the observable universe.

Did You Know?

Approximately 70,000 people called a special 900 number during the third flight of Columbia to monitor the air-to-ground commentary. NASA plans to offer this same service for the fourth Space Shuttle flight, scheduled for launch June 27. The phone exchange, (900) 410-6272, will operate 1-2 hours before launch through end of mission.

The Space Shuttle Columbia was the topic of a promotional campaign by Cherrios cereal and proved to be big business. For three box tops, kids could receive a Shuttle booklet and kit (consisting of a decal and an iron-on patch for t-shirts). For an additional dollar, they could receive a balsa/styrofoam model of the spacecraft. By April 1, the company had received over 350,000 responses (representing over a million boxes of cereal sold) for the booklet and kits; over half that figure had enclosed the money for a Shuttle model.

NASA Lewis aeronautics engineer **Peggy L. Evanich** has received the prestigious **Distinguished New Engineer Award** presented by the National Society of Women Engineers. Evanich is now participating in a one-year training period in a Headquarters career development program where she has been assigned to the Office of Aeronautics and Space Technology Transport Aircraft office working on programs that parallel her job at Lewis: studying the effects of icing on aircraft structures, propellers and engines. Evanich was cited for her outstanding and sustained efforts as project manager of aircraft icing research programs.



Early Results Look Good—NASA and university scientists who worked on the Marshall Space Flight Center-managed Monodisperse Latex Reactor experiment flown during the third flight of Columbia say they are "highly elated" by early results from the experiment. The latex reactor is designed to produce identical micron-sized beads in space that can be used for calibration of scientific and industrial equipment and also has potential major medical research applications. The experiment consists of four small metal cylinders, each containing a latex recipe, housed in square electronics packages encased in a metal drum. Early indications are that during the Shuttle mission, the latex beads were grown from their initial size of 2.5 microns to possibly twice that size. A key element in the experiment is to produce the particles in monodisperse, or identical size quantities. Dale Kornfield, of Marshall's Space Sciences Laboratory and co-investigator on the Monodisperse Latex Reactor experiment, pours the latex mixture produced in space during STS-3. He is assisted by co-investigator Mohamed S. El-Aasser (right) and Principal Investigator Dr. John W. Vanderhoff, (standing) both of Lehigh University.

Patents for Inventions from NASA Research

The office of General Counsel, NASA Headquarters, announces that the following U.S. patents have been issued by the U.S. Patent and Trademark Office to NASA for inventions resulting from NASA research. Inquiries concerning them should be directed to the attention of the NASA Patent Counsel of the indicated installation.

Inventor(s) & Employer	Title	Patent No.	Installation
Charlie M. Jackson, Jr., Samuel M. Dollyhigh and David S. Shaw, NASA/LaRC	Metric half-span model support system	4,327,581	LaRC
Thomas J. Pivirotto, Caltech/JPL	High power metallic halide laser	4,328,464	NRO/JPL
Alain L. Fymat, Caltech/JPL	Frequency-scanning particle size spectrometer	4,329,053	NRO/JPL
Richard P. Johnston Malcolm H. Knapp and Charles E. Coulson, General Electric, Cincinnatti, Ohio	Active clearance control system for a turbomachine	4,329,114	LeRC
Bruce A. Banks, Albert J. Weigand and James S. Sovey, NASA/LeRC	Texturing polymer surfaces by transfer casting	4,329,385	LeRC
Wolf Elber, NASA/LaRC	Means for controlling aerodynamically induced twist	4,330,100	LaRC
Paul J. Shlichta, Caltech/JPL	Electromigration process for the purification of molten silicon during crystal growth	4,330,359	NRO/JPL
Jack W. Holt, Donald D. Helman and Laurence W. Smiser, Rockwell International Corp., Downey, Calif.	Method for repair of thin glass coatings	4,330,572	KSC
Joseph S. Heyman, NASA/LaRC	Acoustic tooth cleaner	4,331,422	LaRC
Robert Richter, Caltech/JPL	Solid electrolyte cell	4,331,742	NRO/JPL
Dean W. Sheibley, NASA/LeRC	Advanced inorganic separators for alkaline batteries	4,331,746	LeRC

Space Shuttle Launches for 1982

Orbiter	Launch Date	Launch Site	Payload
*Columbia (OV-102)	March 22	KSC	OSS-1
Columbia (OV-102)	June 27	KSC	DOD 82-1
Columbia (OV-102)	November	KSC	SBS-B

* Successful launch

Expendable Launches for 1982

Name	Launch Date	Vehicle	Range	Mission Remarks
*RCA-C[1]	January 15	Delta	ESMC	RCA communications. Reimbursable.
*Westar-IV	February 25	Delta	ESMC	Western Union communication. Reimbursable.
*Intelsat V-D	March 4	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
*Insat 1A	April 8	Delta	ESMC	India communications. Reimbursable.
*Westar-V	June 8	Delta	ESMC	Western Union communications. Reimbursable.
Navy 21	October	Scout	WSMC	DOD transit. Reimbursable. Callup.
Landsat-D	July 9	Delta	WSMC	NASA earth resources applications.
Telesat-G (Anik-D1)	August 12	Delta	ESMC	Canada communications. Reimbursable.
Intelsat V-E	September	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
RCA-E	October	Delta	ESMC	RCA communications. Reimbursable.
San Marco-D/L	November	Scout	ESMC	International cooperative/Italy.
Intelsat VA-A	December	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.

* Successful launch

Another Dividend from Air and Space

Research and development in aeronautics and space have provided numerous benefits for all Americans—and at a tiny percentage of the tax dollar. Here is an example:

Improved Mine Safety

A device developed by NASA's Langley Research Center to accurately measure bolt stress within wind tunnels could offer a way to improve the nation's mine safety.

Within wind tunnels, bolted segments must withstand high pressures. Langley's Pulse Phase Locked Loop monitor* is an ultrasound system that measures the stress that occurs when a bolt becomes elongated in the process of tightening. The instrument transmits sound waves to the bolt being fastened and receives a return signal indicating changes in bolt stress. It measures the effective changes in resonance due to elongation and changes in sound velocity due to strain. The results are translated into a digital reading of the real stress on the bolt.

Langley, in cooperation with the Department of the Interior's Bureau of Mines, has developed a version of the monitor to check bolt stress in the roofs of mine tunnels where mammoth bolts several feet long extend far into solid rock. Use of the instrument increases safety by assuring proper preloading of roof bolts. Langley and the Bureau of Mines plan to modify the monitor to measure stress of the rock surrounding the tunnel which would serve as a hazard warning. Rock stress varies from mine to mine and may change over time. If rock stress measurement proves feasible, it could provide broad benefit to such related activities as earthquake prediction. In photo the Langley-developed bolt monitor tests bolt stress at the Colorado School of Mines Experimental Mine Facility.

* NASA does not endorse commercial products developed as a result of its Technology Utilization or Patent Licensing Programs, but it does encourage the widest possible use of its technology.

NASA
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For the benefit of all . .